

CLAIMS

What is claimed is:

- 1. A method of measuring the rate of permeation of gases or vapours or mixtures thereof through a test sample comprising:**
providing an amount of gas or vapour in a gas container at a certain vapour or gas pressure; arranging the container containing the gas or vapour in a vacuum chamber, which is under vacuum such that the gas or vapour permeating from the container through the test sample communicates with the vacuum chamber under vacuum;
providing a means to change the relative position between the gas container with the test sample and a mass spectrometer for position resolved measurement of permeation;
using a mass spectrometer to detect the partial pressure of the gas or vapour after permeation through the test sample;
and estimating the rate of permeation from the signal measured by a mass spectrometer.
- 2. The method as claimed in claim 1 wherein the gas container comprises a body, to which one or more test samples are attached forming a seal.**
- 3. The method as claimed in claim 2 wherein one or more of the remaining openings of the body of the gas container are used to accommodate a closing device such as a valve to separate the interior of the gas container from its surrounding the outside.**
- 4. The method as claimed in claim 1 where the pressure decrease inside the gas container due to permeation is compensated by a flexible device that can change its inner volume.**
- 5. The method as claimed in claim 2 wherein the test sample is sealed to the gas container by pressing the test sample against a sealing face of the gas container with or without using a gasket.**
- 6. The method as claimed in claim 2 wherein the test sample is sealed to the gas container by an adhesive.**
- 7. The method as claimed in claim 2 wherein the test sample is a film.**

8. The method as claimed in claim 1 where the gas container is filled with gas or vapour inside a vacuum chamber.
9. The method as claimed in claim 8 where the gas container is filled through a hole with a closing device communicating with a filling chamber filled with a gas or a vapour.
10. The method as claimed in claim 9 where the closing device is operated by means of a tool on a feedthrough.
11. The method as claimed in claim 2 where the temperature of the gas container with the test sample is changed by cooling or heating over a wide temperature range, including cryogenic temperatures.
12. The method as claimed in claim 2 wherein the test sample is made of a polymer, a metal, a ceramic, a biological material or a combination thereof.
13. The method as claimed in claim 1 where the partial pressure is measured with the mass spectrometer after the signal has stabilised to a constant value.
14. The method according to claim 1 where the rate of permeation of a gas or vapour is determined from the partial pressure (measured by a mass spectrometer) and calibration against the rate of permeation of gas or vapour of reference samples.
15. The method according to claim 14 where the partial pressure measured from the reference samples is used for calibration.
16. The method according to claim 1 where the experiment is carried out in a high vacuum (HV), ultra-high vacuum (UHV) chamber or extra-high vacuum (XHV) chamber under vacuum.
17. The method according to claim 1 where the vapour is water vapour.
18. A method of measuring the rate of permeation of water vapour through a test sample comprising:

providing an amount of water vapour in a container at a certain relative humidity;
arranging the container containing the water vapour in a vacuum chamber under vacuum
such that the water vapour permeating through the test sample communicates with the
vacuum chamber under vacuum;
using a mass spectrometer to detect the partial pressure of the water vapour after
permeation of the water vapour through the test sample;
providing a means to change the relative position between gas container with test sample
and a mass spectrometer;
and deriving the rate of water vapour permeation from the signal measured by a mass
spectrometer.

19. The method as claimed in claim 18 wherein the gas container comprises a body, to
which a test sample is attached forming a seal covering an opening of the body of the gas
container.
20. The method as claimed in claim 19 wherein one or more of the remaining openings of
the gas container are used to house a closing device such as a valve to separate the interior
of the gas container from its surrounding.
21. The method as claimed in claim 19 wherein the test sample is a film
22. The method as claimed in claim 18 where the gas container has a movable part for
changing the internal volume.
23. The method as claimed in claim 18 where the gas container is filled with water vapour
inside a vacuum chamber.
24. The method as claimed in claim 18 where the gas container is filled through a hole with
a closing device inside a vacuum chamber with water vapour.
25. The method as claimed in claim 18 where the gas container containing a reservoir with
water vapour is filled with vapour from this reservoir.
26. The method as claimed in claim 18 where the water vapour pressure can be changed.

27. The method as claimed in claim 18 where the temperature of the gas container with the test sample is changed by cooling or heating.
28. The method as claimed in claim 19 wherein the test sample is made of a polymer, a metal, a ceramic, a biological material or a combination thereof.
29. The method as claimed in claim 18 where the partial pressure is measured with the mass spectrometer after the signal has stabilised to a constant value.
30. The method according to claim 18 where the rate of permeation of water vapour is determined from the partial pressure as measured by a mass spectrometer and calibration against the rate of permeation of water vapour of reference samples.
31. The method according to claim 18 where the experiment is carried out in an ultra-high vacuum (UHV) chamber under vacuum or in a extra-high vacuum (XHV) chamber under vacuum or in a high vacuum (HV) chamber under vacuum.
32. The method according to claim 19 where the effective permeation area of the test sample is a few mm or less in one or two dimensions.
33. The method as claimed in claim 19 where the gas container contains a salt solution, which produces a characteristic relative humidity inside the gas container.
34. The method as claimed in claim 18 where the signal to noise ratio of the signal detected by the mass spectrometer is reduced by choosing a suitable isotope from D₂¹⁶O, D₂¹⁷O, D₂¹⁸O, H₂¹⁶O, H₂¹⁷O, and H₂¹⁸O.
35. The method according to claim 18 where the rate of water vapour permeation is determined from the partial pressure as measured by a mass spectrometer and calibration against the partial pressure of one or more samples with a known rate of water vapour permeation.

41. The method according to claim 1 where the gas container has a movable part for changing the internal volume of the gas container.

46. A method for position-resolved permeation measurements at different locations on the test sample comprising:

providing an amount of gas or vapour in a gas container at a certain vapour or gas pressure; arranging the container containing the gas or vapour in a vacuum chamber, which is under vacuum such that the gas or vapour permeating from the container through the test sample communicates with the vacuum chamber under vacuum;

positioning the test sample close to an enclosure housing a mass spectrometer, where the enclosure has a conical bottom with a hole and a tube attached to the hole;

providing a means to change the relative position between the gas container with the test sample and a mass spectrometer in an enclosure for position resolved measurement of permeation;

using a mass spectrometer to detect the partial pressure of the gas or vapour after permeation through the test sample;

and estimating the rate of permeation position-resolved from the signal measured by a mass spectrometer.

50. An apparatus for measuring the rate of permeation of a gas or vapour (including water vapour) consisting of:

one or more vacuum chambers,

a gas container which is removable from the vacuum system,

a filling facility,

a mass spectrometer for partial pressure measurement,

a means for changing the relative positions of mass spectrometer and test sample and

a means of transferring the gas container with the test sample.

51. The apparatus according to claim 50 having a gas container that can be filled by means of a filling facility provided in one of the vacuum chambers.

52. The apparatus according to claim 50 with the investigation chamber is under HV, UHV or XHV conditions.

53. The apparatus according to claim 50 where the gas container can be moved between vacuum chambers and removed from the vacuum chambers.
54. The apparatus according to claim 50 where the size of test sample is less than a mm to a few mm in one or two dimensions.
55. The apparatus according to claim 50 where the test sample is clamped or glued to the gas container.
56. The apparatus according to claim 50 where the test sample is a film or a device or an assembly of several parts of a device.
57. The apparatus according to claim 50 where the gas container contains gas or vapour including water vapour.
58. The apparatus according to claim 50 where the pressure of the gas or vapour inside the gas container can be varied by means of a movable part for changing the internal volume of the gas container.
59. The apparatus as claimed in claim 50 where the partial pressure is measured with the mass spectrometer after the signal has stabilised to a constant value.
60. The apparatus according to claim 50 where the rate of permeation is estimated from the measured partial pressure and a calibration against one or more samples with a known rate of permeation.
61. The apparatus according to claim 50 where the temperature of the test sample can be varied.
62. The apparatus according to claim 50 where the mass spectrometer has an enclosure, which can be pumped.